HAL
open science

Compared model of formation of AU, SN-W, and TA-NB-Li-SN ore deposits within the tras-os-montes domain of the hercynian orogen (NW Spain). The role of intrusion on the mineralogical and fluid inclusion characteristics.

Eric Gloaguen, M. Cathelineau, M.C. Boiron, C. Marignac, Catherine Lerouge, S. Fourcade, Yannick Branquet, Alain Chauvet, Vincent Bouchot, Maxime Le Goff

To cite this version:

Eric Gloaguen, M. Cathelineau, M.C. Boiron, C. Marignac, Catherine Lerouge, et al.. Compared model of formation of AU, SN-W, and TA-NB-Li-SN ore deposits within the tras-os-montes domain of the hercynian orogen (NW Spain). The role of intrusion on the mineralogical and fluid inclusion characteristics.. Colloque Transmets, Jul 2006, Nancy, France. pp.115-119. hal-00107417

HAL Id: hal-00107417

https://insu.hal.science/hal-00107417v1

Submitted on 18 Oct 2006

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

COMPARED MODEL OF FORMATION OF AU, SN-W, AND TA-NB-LI-SN ORE DEPOSITS WITHIN THE TRAS-OS-MONTES DOMAIN OF THE HERCYNIAN OROGEN (NW SPAIN). THE ROLE OF INTRUSION ON THE MINERALOGICAL AND FLUID INCLUSION CHARACTERISTICS

E. Gloaguen[a], M. Cathelineau[b], M.-C. Boiron[b], C. Marignac[c], C. Lerouge[d], S. Fourcade[e], Y. Branquet[a], A. Chauvet[f], V. Bouchot[d] and E. Le Goff[d]

[a] *ISTO, UMR 6113 CNRS/Université d'Orléans, Bât. Géosciences, Rue de St Amand, BP 6759, 45067 Orléans Cedex 2, France. eric.gloaguen@univ-orleans.fr*
[b] *CREGU & UMR G2R CNRS 7566, BP 23, 54501 Vandoeuvre lès Nancy cedex, France*
[c] *CRPG, 15 rue Notre Dame des Pauvres, 54501 Vandoeuvre lès Nancy, France*
[d] *BRGM, 3, avenue Claude Guillemin, BP6009, 45060 Orléans Cedex 2, France.*
[e] *Géosciences Rennes, UMR CNRS 6118, Campus de Beaulieu, Av. du Gal Leclerc, 35042 Rennes cedex, France*
[f] *UMR 5573 - Laboratoire Dynamique de la Lithosphere, ISTEEM, Université Montpellier 2, CC. 60, 34095 Montpellier cedex 5, France.*

Travaux réalisés dans le cadre du GdR Transmet

1. Introduction and geological setting

The study area is located in the Galicia-Trás-os-Montes Zone (GTMZ zone, Arenas et al. 1986; Farias et al. 1987 Fig. 1) a part of the Iberian hercynian massif. The GTMZ belongs to the internal zone of the Hercynian belt and is composed of a relative autochthonous and parautochthonous units overthrusted by allochthonous complexes. Studied area is located in the Schistose Domain (parautochthonous Marquínez García 1984) which is composed by a monotonous sequence of schists. Rocks of this domain exhibit a well-developed regional schistosity related to nappes emplacement (D1 and D2 events) and are affected by NS-trending crenulation and folds (D3 event) characterized by a high-temperature metamorphism leading to local development of migmatites. Four generations of granites (G1 to G4), well identified in NW Spain by their textural, geochemical characteristics and crosscutting relationships are present in the studied area. G1 to G3 granites are coeval with late with D3 event. G1 granites are syn-kinematic porphyric biotite granites. G2 granites are syn-D3 two micas granites and leucogranites (Capdevila and Floor 1970; Barrera Morate et al. 1989). G3 granites are biotite-dominant two mica granites (Barrera Morate et al. 1989). G4 granites are post D3 (Capdevila and Floor 1970; Bellido Mulas et al. 1987; Barrera Morate et al. 1989). Gold mineralizations are spatially associated with G3 granites, and Bruès, the main deposit, is located on the North-western edge of the Boborás granite roof (fig. 1). Sn-W deposits are represented, by disseminated and vein-type mineralizations. Sn,Ta,Li,Nb±W disseminated mineralizations are hosted by REE-pegmatites-aplites (Fuertes-Fuente and Martín-Izard 1998), crosscut by Sn-bearing quartz veins, spatially associated with G2 granites. The main pegmatite field is the Couso district, located on the Eastern edge of the La Estrada-Cerdedo G2 granite (fig 1). Sn-W±Ta±Nb vein-type deposits are also spatially associated with G2 granites. The most important deposits are located on the Eastern edge of the composite G1-G2 Beariz granite (fig 1).

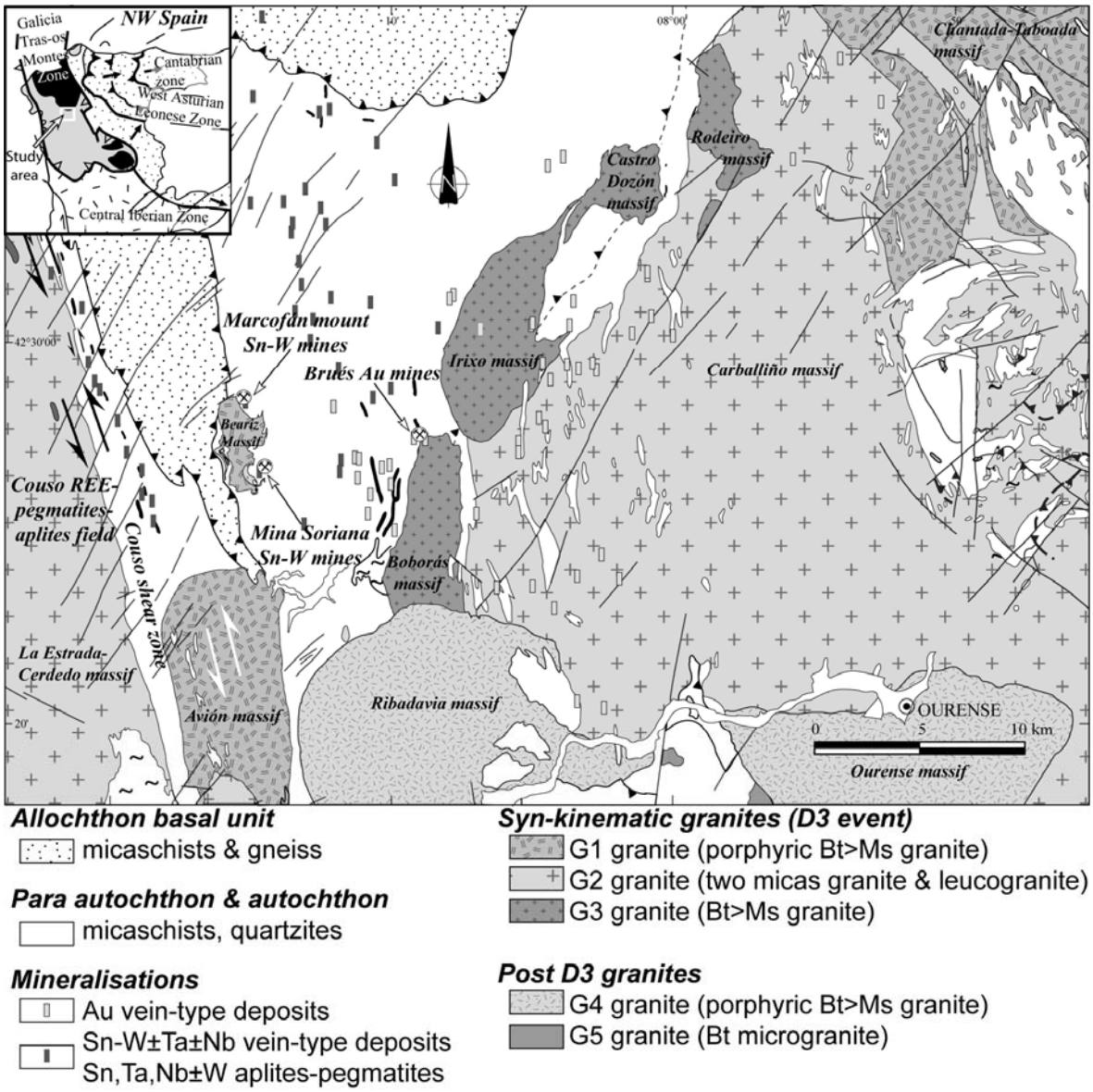

Fig. 1. Localisation of the studied area in NW Spain (inset on the top left corner) and geological map of the studied area. Localisation of Au and Sn-W vein-type deposits are also indicated. Note the spatial relationship between G3 granites & Au deposits and G2 granites & Sn-W deposits.

2. Relations between granites and mineralizations

2.1 Spatial and structural relations

In the studied area, G2 and G3 granites exhibit close spatial relationships respectively with Sn-W±Ta±Nb and Au deposits (fig. 1). Structural, gravimetric and petrological studies have been realized on each type of deposits (Au veins of Brués ; Sn-W veins of Bearíz ; REE pegmatites and quartz veins of Couso) in order to constrain tectonic controls from granites intrusion to deposits emplacement. Main results are as follow (see details in Gloaguen et al, this volume): i) emplacement of magmatic bodies (G1 to G3 granites; G2 pegmatites) controlled by the D3 E-W compressive event; ii) focalisation of mineralized veins in local extensive areas on the roof of granites; iii) mineralizations are systematically hosted by magmatic sills and dykes; iv) characterization of mineralized quartz veins process of formation compatible with a North normal motion ; v) a continuum

of deformation from granite intrusion to veins formation, well-marked by the evolution of structure and filling (granite dykes, aplite-pegmatite dyke, feldspars-micas-quartz veins, K-feldspar-quartz veins, quartz veins) suggests a magmatic-hydrothermal continuum controlled by the D3 event regional tectonics ; vi) a high temperature deformation of quartz veins on the first quartz filling of the veins (chessboard textures, plastic deformation of quartz) traduce the persistence of magmatic conditions.

2.2 Chemical and mineralogical relations

Whole-rock analyses (ICP-AES & ICP-MS) have been realized both on magmatic bodies and mineralized structures. Major and trace elements from granites have distinct distribution following the nature of the intrusive. The G3 granites, hosting gold deposits, are un-fractioned intermediate I-S type peraluminous reduce monzogranites whereas G2 granites are fractioned peraluminous reduce S-type granites and leucogranites. By comparison with G2 granites, the G3 are poor in most of trace elements from upper continent crust and, relatively rich in Ba, Cr, Ni, Sr, V and Sb. The composite Beariz massif is formed by a G1-type granite intruded by small G2 albite-rich specialised tourmaline-garnet leucogranites (with up to 106 ppm Sn and 43 ppm Ta). Results suggest than G2 granites originate from an upper crust metapelitic garnet-bearing source whereas G3 can issued from at least two origins, a metapelitic source and a basic one, that can be amphibolite (lack of feldspars in the source).

Mineralogical (EPMA) and whole rock analyses from mineralizations and hydrothermal alterations haloes show a very similar paragenetic evolution for all type of deposits. The first stage is essentially quartz-rich, the second is characterized by arsenopyrite occurrence, and the third stage is marked by bismuth minerals located within arsenopyrite fractures (associated with gold in Bruès). Temperatures given by various geothermometers (muscovite-phengite, chlorite) from stage I veins and alteration minerals range between 650 and 400°C. The main differences are: i) the Sn-W±Ta±Nb ore is precoce within magmatic bodies (disseminated in aplite-pegmatite) or in the early quartz filling of veins whereas gold is late; ii) the hydrothermal alteration is strong for Sn mineralizations (tourmalinites, greisen, F-rich tourmalines and F-rich muscovites within neighbouring rocks of intrusive features) and only restricted around Au mineralized veins; iii) the Au-related arsenopyrites are characterized by the presence of Co, Sb, Se and Ni, not observed in Sn-related ones; iv) bismuth minerals (bismuthinite, native bismuth) in Au quartz veins are marked by presence of antimony whereas Sn-bearing veins contain free-Sb bismuthinites, that systematically contain stannite and are characterized by the lack of Au and Te-bearing minerals. The presence of stannite in the third stage of veins filling suggests that this late stage is not temporally disconnected from the early stage within cassiterite-bearing veins.

2.3 Fluids relations

Fluid Inclusions and stable isotopes studies have been performed on different quartz generations (Q1, Q2a, Q2b, Q3) of Sn-W and Au veins. Fluids inclusions studies (microthermometric data and bulk compositions determined by Raman spectrometry) show a strong domination of aqueous-carbonic±CH_4±N_2 fluids in the two veins systems (Sn-W and Au) and a late introduction of low-salinity aqueous fluids. In Au-bearing veins, aqueous-carbonic fluids inclusions yields low-salinity (10-16.2 to 6-10 wt. % eq. NaCl) with homogenisation temperatures (Th) ranging

from 300 to 350°C. Aqueous low salinity inclusions displays a large range of Th varying from 140-175°C; 210-235°C and 350°C. High salinity inclusions characterized by the presence of halide cube and solids (carbonates) with high Th (322-333°C) have been also observed in early Q1 quartz. Identification of complex aquo-carbonic inclusions with halide cube and carbonates suggests high temperature mixing between high-salinity aqueous fluid and aqueous-carbonic±CH4±N2 fluids during early stages of veins formation. Fluids and evolutions are similar for Sn-W veins. Nevertheless, high-salinity fluids have not been observed and fluids temperatures are slightly more elevated, in the range of 305-418°C.

Oxygen and hydrogen compositions have been determined on separates minerals (quartz, biotite, muscovite, garnet, tourmaline) and on whole rock samples for each granite generation, host micaschists, vein-type mineralizations and alteration haloes (tourmalinites, greisens). $\delta^{18}O$ and δD of fluids in equilibrium with mineralogical assemblages have been estimated from $\delta^{18}O$ and δD of separated minerals, mineral-H_2O fractionations, and equilibrium temperatures. Temperatures estimations for mineralizations are constrained by fluids inclusions data and geothermometers (muscovite-phengite, chlorite). Results show a similar evolution for fluids of the two veins systems: i) granites are in equilibrium with fluids between 8 ‰ (G3 granite) and 9 ‰ (Beariz G2 specialized granite); ii) G2 and G3 intrusive bodies in host micaschists (granite and aplite-pegmatites sills and dykes) show an enrichment in ^{18}O of 2 ‰ interpreted as an high-temperature interaction with micaschists; iii) early quartz of mineralized veins are in equilibrium with a fluid between 9-10 ‰ during cooling until 400-450°C; iv) inversely, the following generations of quartz (Q2a to Q3) are not in equilibrium with the earliest fluids at 9-10 ‰, which is interpreted as an introduction of meteoric external fluids, depleted in ^{18}O, in the two veins systems.

3. Discussion-conclusion

The spatial relation between mineralization and G2/G3 granites, the continuum of deformation, the presence of transitional veins between granite and pegmatite-aplite compositions, the high temperature of hydrothermal quartz deformation and the same tectonic control between granite emplacement and veins formation at the end of D3 event are strongly in favour of a temporal link between granites emplacement and veins systems formation, under a regional tectonic control. The chemical and mineralogical differences of Au and Sn-W parageneses are marked by the presence of Co, Cr, Ni, Sb in sulphides of Au veins, whereas these elements are not observed in Sn-W systems. In the same way, hydrothermal alterations are quantitatively and qualitatively very different (strong alteration in Sn-W systems with F-rich tourmalines and muscovites). These differences could be correlated with geochemistry of granites from each system. This is in favour of link between mineralizations and granites in terms of chemical signature. Evidence of aqueous-carbonic fluids, high salinity inclusions and the results of stables isotopes studies are also in agreement with, at least, a contribution of magmatic fluids in the hydrothermal system. All these elements are compatible with a thermal and structural role of granites for ore formation, and suggest a possible genetic link between i) Au and G3 magmas ; ii) Sn-W±Ta±Nb and G2 magmas, even if a direct relation between these elements and magma could not be directly demonstrated.

4. References

Arenas R, Gil Ibarguchi JI, González Lodeiro F, Klein E, Martínez Catalán JR, Ortega Girones E, de Pablo Macía JG, Peinado M (1986) Tectonostratigraphic units in the complexes with mafic and related rocks of the NW of the Iberia. Hercynica II: 87-110.

Barrera Morate JL, Farias Arquer P, González Lodeiro F, Marquínez García JL, Martín Parra LM, Martinez Catalán JR, del Olmo Sanz A, de Pablo Macía JG (1989) Memoria de la Hoja, Ourense/Verín (17/27). Instituto Geológico y Minero de España, Madrid.

Bellido Mulas F, González Lodeiro F, Klein E, Martínez Catalán JR, Pablo Macía JG (1987) Las rocas graníticas hercínicas del norte de Galicia y occidente de Asturias. IGME, Madrid.

Capdevila R, Floor P (1970) Les différents types de granites hercyniens et leur distribution dans le nord ouest de l'Espagne. Bol. Geol. Min. España 81: 215-225.

Farias P, Gallastegui G, González Lodeiro F, Marquínez J, Martín Parra LM, Martínez Catalán JR, de Pablo Macía JG, Rodríguez Fernández LR (1987) Aportaciones al conocimiento de la litoestratigrafía y estructura de Galicia Central. Mem. Fac. Ciênc. Univ. Porto 1: 411-431.

Fuertes-Fuente M, Martín-Izard A (1998) The Forcarei Sur rare-element granitic pegmatite field and associated mineralization, Galicia, Spain. Canadian Mineralogist 36: 303-325.

Marquínez García JL (1984) La geología del área esquistosa de Galicia Central (Cordillera Herciniana, NW de Espana) Instituto Geológico y Minero de España, Madrid, pp 213 p.